DEVELOPMENT OF A REVISED GREAT LAKES SHORELINE CLASSIFICATION SYSTEM AND RECOMMENDATIONS FOR APPLICATION TO THE LAKE MICHIGAN SHORELINE

LAKE MICHIGAN POTENTIAL DAMAGES STUDY

BACKGROUND

In March of 1993, the International Joint Commission completed the 1986-1993 Reference Study of Water Level Fluctuations in the Great Lakes - St. Lawrence River basin. As part of this work, the Erosion Processes Task Group had developed a three-tiered shoreline classification scheme for the Great Lakes that took into account factors related to the overall erodibility of the shoreline.

The shore "type" classification developed was specifically created to capture those elements of the shore character which may be important to consider when examining the response of the shore to lake level fluctuations. The first tier was a typing based strictly on the geomorphic nature of the shoreline (e.g. whether it is a dune-beach complex or a bluff). Using the base of scientific knowledge that currently exists regarding types of shorelines found throughout the basin, 17 categories were developed for this tier:

1) High (>15m) Bluff
2) High (>15m) Bluff With Beach
3) Low (<15m) Bluff
4) Low (<15m) Bluff With Beach
5) Sandy / Silty Banks
6) Clay Banks
7) Sandy Beach / Dunes
8) Coarse Beaches
9) Baymouth-Barrier Beaches
10) Bedrock (Resistant)
11) Bedrock (Non-Resistant)
12) Low Riverine / Coastal Plain
13) Open Shoreline Wetlands
14) Semi-Protected Wetlands
15) Composite
16) Artificial (for Canada; Unclassified for U.S.)
17) Unclassified (for Canada; Artificial for U.S.)

The second tier of information was the amount of shore protection present in a specific reach of shoreline. No judgements were made as to the effectiveness and quality of the protection, but instead only on the percentage of shoreline that was protected within the reach. Similarly, the classification did not specify the type of structural protection in place. The primary reason for this being that the majority of

the information was derived from air photos and mapping products. As a result, it was difficult to determine the quality and effectiveness of the structures. There were 6 categories developed for this tier:

1) Highly Protected: 70-100% of reach / segment protected.
2) Moderately Protected: 40-70% of reach / segment protected.
3) Minor Protection: 15-40% of reach / segment protected.
4) No Protection:>85% of reach/segment is unprotected.
5) Non-structural
6) Unclassified

Finally, as it is becoming increasingly apparent that the erosion of the nearshore, sub-aqueous portion of the shore profile (referred to as downcutting) is a key agent in the overall recession and erosion of the shoreline, a third tier was developed to describe the nearshore (sub-aqueous) shore type. This was a simple geomorphic classification of the type of material found in the nearshore zone and consisted of 6 categories:

1) Clay
2) Sand
3) Sand / Gravel Lag Over Clay
4) Bedrock (Resistant)
5) Bedrock (Non- Resistant)
6) Unclassified

The classification scheme was also designed to be:

- cross-shore oriented (i.e. insensitive to littoral effects);
- inclusive of all the Great Lakes and Connecting Channels;
- a generic grouping into which clusters of parameter details could be grouped;
- generally and visually meaningful;
- based on data extractable from aerial photos, maps and literature (i.e. no site visits); and
- key on parameters which are important in terms of shore erodibility

LIMITATIONS OF THE CLASSIFICATION SCHEME

While the shore classification scheme and the resulting database of classification information provided a comprehensive attempt to recognize and quantify the complex nature of the Great Lakes shoreline, there were some limitations that arose, primarily due to time and budget constraints associated with the Reference Study:

1) The United States shoreline was classified using various published and unpublished data sources, photographs, and personal knowledge. The mappers

proceeded by reviewing their materials and writing the shore type, protection level, and offshore type on U.S Geological Survey topographic quadrangles. The quadrangles were then sent to USACE Detroit District, where the classifications were entered into a Geographical Information System (GIS) database. Note that the quadrangles were used merely as a convenient base upon which the mappers could write their classifications and notes. The shorelines in the GIS database are not based on the quadrangles but rather on recent aerial photographs. Many portions of the shore, especially along barrier spits and sandy coasts, have changed significantly since the maps were printed. In addition, man-made structures have caused major changes in some areas. This may result in inaccuracies in shore type boundaries or misclassification of shore types.

2) Although the classification of several shore sections were re-evaluated to cross-check the initial classification, there was insufficient time to conduct a broad ranging quality control check. Therefore there are undoubtedly some sections of the shoreline which were mis-classified and cases where similar shores may have been interpreted into different classes.

3) The limited time and budget allocated to the study did not allow for additional data collection or for field verification of the classification. In addition, several different coastal geological experts were used to apply the classification scheme across the basin. This resulted in some variability in interpretation, particularly between the U.S. and Canada, and between different lakes on the U.S. side.

4) The variability in descriptive data throughout the literature, between states and across Canada, the limited availability of recent good-quality aerial photography and/or oblique video tapes, the lack of information on nearshore geology and bathymetry, and the generality of the classification scheme, made it impossible to assure an equal level of quality and detail in the classification across the basin.

5) The protection classification scheme developed for this reference study does not recognize the quality of the protection, only the percentage of shoreline covered. To be true to the purposes of the classification scheme, verification is needed that a "heavily protected shore" is engineered to provide a predictable design life and level of protection.

6) Additional data is needed on nearshore geology and bathymetry (including nearshore slope). The six classes utilized were fairly basic. Further refinements based on a better knowledge of offshore stratigraphy and lithology, as well as the degree of sand cover are required.

A number of other issues and limitations were identified in the Erosion Processes Task Group Report.

OPPORTUNITIES FOR IMPROVEMENT / REVISION

With renewed interest in the classification scheme through the Lake Michigan Potential Damages Study, there is now an opportunity to revise and improve the classification scheme so that the above limitations can be removed, or at least significantly reduced.

REVISION ACTIVITIES

In undertaking the revision of the classification scheme, a number of activities were undertaken. First, detailed discussions were held with LMPDS Study Team members (primarily staff of USACE Detroit District and CHL, and other consultants) who provided a number of alternatives and possibilities relative to the existing limitations and relative to how the scheme was to mesh with the potential damages "model" that was to be developed in the LMPDS. This resulted in the development of a "Strawman" Classification that was then distributed to the Study Team as well as to other interested parties.

Comments on the Strawman Classification were compiled and used as a focus of discussion at a Shoreline Classification Revision Meeting that was held in Chicago in June of 1997. This meeting included staff of various USACE offices, other consultants involved in the Study, as well as interests from other state agencies (e.g., State of Ohio, State of Illinois). A thorough discussion of all issues was held and an attempt at consensus was made in order to reach decisions on any classification issues.

A Draft Revised Shoreline Classification Scheme was prepared following the above meeting and was circulated to Study Team Members as well as to members of the LMPDS Advisory Committee that was established in January of 1997. This revised scheme was then presented to the Advisory Committee at a Study Update meeting in September of 1997. Comments received at this meeting were incorporated and a final revised classification scheme was prepared.

A DISCUSSION OF CLASSIFCATION ISSUES AND CHANGES

The following presents a summary discussion of the various shoreline classification issues that arose and the final decisions made by the Study Team on them.

Geomorphic Classification

Issue #1: Inclusion of "Artificial" Classification

In the original classification, the artificial category was applied to the waterfront of cities or industrial sites where the indigenous geology was essentially buried in concrete or surrounded by man-made structures. The intent was that the natural geology of the setting now played only a limited role in recession and other coastal geologic processes. Many of these sites contained large amounts of fill and projected out into the lakes, protected by seawalls. This classification was also applied to railroads or highways which paralleled the shore and were protected by riprap or seawalls. Although the amount of artificial coverage was less than at cities or factories, the shoreface had been protected to a degree where recession was no longer a function of erosion of the underlying geology.

It was argued that this category may more suitably be shifted to the Shore Protection Classification tier. Certainly from a pure geologic point of view, an artificial shoreline does not belong in the same category as a sandy beach or cohesive bluff as it is not a geomorphic shore type. Given that all of these types of shorelines also classed as "highly protected" in the protection classification tier, it may be suitable to drop the category from the geomorphic classification. The question then becomes what to do with these shore types from a geomorphic point of view? Do we class them according to their underlying or historic geology? Do we class them according to their surrounding or neighboring shore type? Or do we leave them be?

Resolution: The general consensus was to leave this as is, as it provides a necessary distinction for those shore types that are no longer in their natural state and now consist of landfill or other hard structures. It represents a significant linear percentage of the shoreline and it should be retained.

Issue # 2: Resistant Bedrock vs. Non-Resistant Bedrock

The classification scheme distinguished between non-resistant bedrock (G11) and resistant bedrock (G10), but it was not defined quantitatively. Moreover, this distinction was not readily apparent on the primary data sources. Some information could be derived from geologic maps and reports, but again, this required matching the description of the rock type with some measure of resistance. Finally in areas of highly variable lithology it was necessary to know the characteristics of the bedrock that was in the subaqueous zone or at the shoreline, which may not necessarily have been the formation that was seen as outcropping on the land.

The question for discussion then, is how much of a difference does resistant vs. non-resistant bedrock make in the overall erodibility of the shoreline, for the backshore or cliff area? In either case, recession will be much slower than on, for example,

cohesive bluffs. Can we combine the two into one category of "Bedrock"? We basically ended up doing this during the erosion sensitivity portion of the work, so why differentiate in the classification scheme? Perhaps this separation is only important in discussing the erodibility of the subaqueous nearshore portion of the beach profile. The initial recommendation here would be to combine them.

Resolution: It was felt that jointed shales and softer shales could and do play an important role in the erodibility of the shoreline. It was also felt that presence of erodible bedrock may also be used as evidence to infer the presence of erodible bedrock underwater. This category distinction should also be retained in order to educate people that sedimentary rock types can be susceptible to erosion (i.e. riparians only see the above water portion of the shore and need to know that these shore types can erode). This category should also be retained so that as future data becomes available we can easily incorporate it to the classification scheme.

Issue # 3: Composite Shorelines

What are they and how do we discern them? This was the biggest issue faced when conducting the classification in the Reference Study. Generally speaking, it was to be applied in a stratigraphic sense to shores where the bluffs were composed of significantly different materials. In practice, it was impossible to distinguish composite bluffs on aerial photographs and additional geological information was necessary to complete the classification. Unfortunately, the geological literature was often unclear regarding the lateral extent of regions where bedrock was exposed along shorelines. Therefore, this classification was used infrequently and was only applied where the classifiers had good evidence of the geologic nature of the shore structure. In fact, only 0.9% of the U.S. shoreline (none on Lake Michigan) and none of the Canadian shoreline fell under this classification.

Given this, and in lieu of detailed field examinations of bluff lithology and stratigraphy, perhaps this category can be dropped from the geomorphic scheme, and for those areas where it was encountered, the category can be changed to the predominate shore type that exists.

Resolution: There was a good deal of discussion on the need to better define what we mean by composite shoreline and the various criteria that might define it - groundwater seeps; homogeneous (non-stratified) vs. heterogeneous (stratified); layered bedding structures; combination of basic shore types (e.g., sand and till, till and bedrock); cohesive vs. non-cohesive. It was generally felt that this would be a suitable subset of the bluff category as it was felt all composite shorelines would be found in bluff settings. Some concern was expressed about the level of effort required to determine where composite shores exist. There is some work on the Wisconsin shoreline, and some by Graham Larson in Michigan. It was felt that geologic information should be available from various states. If we retain this classification, we can build this database over time as we gather the information.

Discussion also focused on the possibility of adding in a confidence factor to indicate "level of comfort" with what is included in the definition of the composite shoreline for a site. The final consensus was that we would eliminate the composite category and make it a subset of the bluff category (subject to further refinement of how we are going to define what makes a composite shoreline). This will require field specific studies to plug into this classification.

Issue # 4: Sandy Beach / Dunes vs. Baymouth Barrier Beaches vs. Semi-Protected Wetlands

A number of problems were encountered in differentiating between these three classes and classifiers had difficulty distinguishing whether such a section of shore should be classified as G7, Sandy Beach / Dune, G9, Baymouth Barrier, or as G14, semi-protected wetland. The classifiers used the width of the sand barrier as the main distinguishing criteria. If the barrier was greater than 10 m (33 ft) wide and had a well developed dune(s) between the wetland and the beach and there was no evidence of interaction between the wetland and the lake (i.e. overwash), the reach was classified as G7. If overwash processes were present, the shore was classed as G9. If the beach was narrower than 10 meters (33 ft) the shore was classed as G14 (see G14 description). Again, it is recognized that this judgement was based on the data available and was influenced by lake water level and season that the aerial photographs or video films were taken.

Arguments could probably be made for combining the baymouth barrier category into the sandy beach / dune category, after all, most baymouth barriers are sand beach environments, so why not show them as such? Also, both respond in a similar fashion to waves, water levels, etc. The key difference then will hinge on the perceived importance of overwash processes and their effect on shore response. If we deem it very important, then we leave the classes as is. As for semi-protected wetlands, we may wish to keep this category, but only have it include wetland areas protected by man-made levees, or by materials other than sand (e.g. cobbles). This however would require re-classifying all areas presently identified as semi-protected wetlands, a task that may be beyond the scope of this activity.

Resolution: It was felt that it may be a key distinction to retain these as separate categories from a sand supply point of view. Sandy beach dune environments are big relic deposits of materials critical for beach building or sand cover in nearshore areas. While it is important to keep the distinction between beach/dunes and baymouth barriers, it was agreed that semi-protected wetlands, where they are diked, or leveed, would fall into the artificial classification, and where they are protected by baymouth barriers, would fall into the baymouth barrier classification. It was felt that they could be called artificially protected wetlands.

Issue # 5: Sandy/Silty Banks vs. Clay Banks vs. Low Plain

A similar argument as above could be made for these three categories. Are there substantial differences in the way these shore types erode to warrant their inclusion as separate categories? If the primary controlling factor is simply related to the degree of relief of the shore type (these are all low features) why not group them as one category, "LOW BANKS" for example. This was done in a mapping exercise conducted with this data for the USGS (although we were largely constrained by map scale).

Resolution: The general consensus was that these three categories could be combined given that the general erosion processes would be the same and where sand content information was required, you could use a subclass to express this. However, what is meant by "low" will need to be defined a bit better. Perhaps these could be considered low bluffs, although not all low plain shorelines would be considered bluffs and thus would not be suitable to include here.

Issue # 6: High Bluff vs. Low Bluff

The only real distinction we seem to have made here regarding the difference between these two categories is that the higher bluffs may be more susceptible to catastrophic bluff failures caused by groundwater seepage, gullying or freeze-thaw cycles. Is this in fact the case? Or are cohesive bluffs less than 15 meters in height subject to the same processes? It may be that the key factor here regarding erosion and recession is the actual composition of the materials (i.e., the cohesive sediments) rather than the height of the feature, and as such, the high and low categories can be combined.

Resolution: It was felt that perhaps we only need the height of the bluff, not necessarily whether it is high or low. Simply call it a bluff and then define through additional attribute information or subclasses the height, sand content, composition, etc. Other thoughts were that we might be better off to approach all cohesive shores with a four tier discriminator such as relative height (high, medium, low with assigned numerics), composition (100-80% clay material, 79-50% clay material, etc.), and finally, relative stratigraphic complexity (homogeneous to highly stratified), and finally the presence or absence of a beach/nearshore sand zone (see below). The scheme has been partly revised to reflect some of this and as a result additional data collection and data entry in the GIS will be required.

Issue # 7 - Beach or No Beach

There was a feeling among some that the presence of a sand beach on a cohesive profile was simply a function of the amount of sand cover present and that the width really had no impact on the protection of the bluff from recession. The presence of a

beach was also felt to be a function of the water level present at the time of classification - lower levels equal wider beach - and that if we were going to retain this class, then we needed a consistent reference water level. There was a bit of an argument about retaining this class for coastal management purposes, i.e., is there any value in knowing that at some point there was a sand beach present in that location.

Resolution: This category has been retained as it might be the only way to document whether or not a particular site would function as a sandy beach during most non-high water/limited storm periods and then flip to cohesive bluff erosion response during events.

Shore Protection Classification

Issues

The biggest issue with the shoreline protection classification was that there were no quantitative judgements made as to the quality and effectiveness of the shore protection, but only on the percent that a particular reach was protected, and whether it was with one structure type (e.g., continuous revetment) or with ad hoc, sporadically spaced structures. While to a degree, this made an assumption that regular continuous structures were of higher quality than the ad hoc structures, there was no quantitative method derived for determining this. Similarly, it was difficult if not impossible to judge anything about the quality of shore protection from the air photos, videos and mapping products used in conducting the initial classification. To really do this properly requires extensive field investigations and observations and comparison of actual conditions against a set of criteria that adequately define or measure the quality of a shore protection structure. Such detailed investigation may be beyond the scope of this study, unless it is conducted in a few select site study areas.

A second point related to shore protection quality is that there needs to be some way of assessing whether or not the type of shore protection present is appropriate for the physical conditions that exist in the reach. For example, we may find a well-engineered, well-maintained set of groins over a reach of 1 km, but if there is no sediment moving alongshore for the groins to trap, then the structure is essentially ineffective and should not fall into a "highly protected" classification as it otherwise probably would.

To overcome the quantification issue a type of ordinal ranking system was initially suggested to "measure" various components of the shore protection present. For example, one might have a check list that looks something like this:

	1	2	3	4	5
Rate the Age of the Structure	Old ----------				----------New
Quality of Materials Used	Poor				Good
	(e.g., cars)			(e.g., armorstone)	
Rate the size of the Units	Small		Medium		Big
Was Engineering Design Used?	No		Some		Yes
Is the Structure Ok for Physical Setting?	No				Yes
Etc., Etc.					

For structures that score 5/5 on all categories, or score above a certain threshold level (e.g., if there are 10 categories = max 50 points, then 45/50), they then fall in the "Highly Protected" category. Structures scoring 3-4 out of 5 (say 35-45) fall into "Moderately Protected", etc. In all cases however, if a structure was deemed NOT appropriate for the physical setting, it would default to the "No or Minor Protection" category.

Again, it would be difficult to use a numerical system like this using air photos and videos as a source. Site investigations would likely need to be completed.

There was also a general feeling that if we bring the shore protection classification level down to the 1 Kilometer reach level, we may avoid any perceived or actual liability issues surrounding quality assessments and engineering judgements regarding specific structures, as well as have data on shore protection type and quality that are compatible with the recession rate database that also exists at this scale.

How then do we estimate quality over such a long reach? While this may be "easier" to do from air photos and other source data (i.e., may not require site visits), we run into a quantification issue again and get into requiring a scheme similar to the existing one, i.e., percentage of reach protected and by what type of structure. Perhaps we make a simple assumption that one type of structure is better than another? Certainly there is probably enough coastal engineering literature that shows that revetments, for example, may be more appropriate than seawalls (in certain settings and for certain shore types) and that any engineered structure is better than property owner dumped sidewalk rubble or rubber tires?

Aside from the above discussion, the 6 categories in this tier seem to be adequate to describe the nature of shore protection in the Great Lakes. There may be an argument for removing the non-structural category as, even without quantification, it provide no indication of quality whatsoever. It only makes up 1.2% of the entire U.S. shoreline and only 0.02% of the Canadian shoreline. Perhaps these can be moved into the "minor" protection category, or else some type of judgement can be made as to which category specific non-structural options should be moved to.

We have also proposed to bring down the "Artificial" category from the Geomorphic classification.

Resolution

It was generally felt that any attempt at all to determine a qualifiable or quantifiable method of evaluating shoreline protection structures would be inappropriate and would lead to too many unanswered questions - How do we rate structures? How do we acquire the data? How do we look at undermining of structures?

It was felt that a more meaningful solution in terms of the modeling would be to determine the original intent of the structure and it's type, in other words, to get a definition of it's primary intent. For example, coastal armoring would be an "intent" and an armorstone revetment would be a "type" of structure in this category.

Questions arose on how to classify in this manner. It was felt that perhaps we could use the initial classification results (e.g., highly protected, moderately protected), examine an area classed as highly protected (for example) and then assess the types of shore protection present in that reach or area and any specific details that would be useful to include in the overall database.

Other questions arose about the validity of including shore protection in the classification at all, since it's role in protecting a bluff may be short-term. In answer to this it was suggested that it is important to be able to model the impact of a shore structure, so that property owners can be shown the benefits (or not) of constructing something. Also from a general modeling perspective, the model wants to know what type of structure, if any, is present along the profile.

Subaqueous Nearshore Classification

Issues

The Nearshore Classification developed for the Reference Study was based on simple geologic categories with no quantifying information associated with it (e.g., thickness of sand layer). Preliminary discussion at the January Planning workshop and with NCE, CHL staff and other contractors have indicated a desire to refine this classification so that it includes more detailed information on items such as:

- slope
- stratigraphy
- lithology
- percent sand cover / thickness

This related primarily to the nearshore composition in areas of cohesive profiles, particularly the degree of sand cover in the nearshore zone. Initial discussions with Study Team members saw a potential for 5 nearshore types to essentially replace

the "Clay" and "Sand / Gravel Lag Over Clay" categories from the initial classification:

1. Thick Sand Cover Over Cohesive Profile (~200 m3/m of sand and gravel)
2. Isolated Bars and Beach Over Cohesive Profile (~100 m3/m of sand and gravel)
3. Minimal Sand Cover Over Cohesive Profile (<50 m3/m of sand and gravel)
4. Concave Cohesive Profile With Sand Veneer
5. Convex Cohesive Profile With Cobble / Boulder Lag / Bedrock

The biggest issue with these categories is how we will acquire this information? Data on nearshore composition has always been scarce and where it exists it usually only refers to the predominant geology present with no consideration of the lithology or stratigraphy present. Some studies have done detailed core analysis and sampling, but they are sporadic. Does new data exist? What form is it in? Is it in a form we can use?

Similar to the discussion in the Geomorphic classification, we also need to assess if there are significant differences in the way the nearshore will erode in areas of resistant bedrock and non-resistant bedrock. This difference did not play a big role in determining erosion sensitivity in the initial classification, so perhaps it may be more appropriate to combine these simply to a "Bedrock" category.

Resolution

Further discussion with Study Team and Advisory Committee members tended to favor the above classification with some minor points of discussion:

1) remove reference to convex or concave, as this should be inherent in the geological nature of the nearshore zone;
2) the classification should be similar to that for the above water shore type, but needs to reflect the amount of sand cover and the presence of any lag deposits;
3) any classification needs to be able to reflect whether this is a sandy profile or not, whether it is a cohesive profile or not and how long it operates this way, or whether it is a bedrock system or not;
4) provide a better definition of cohesive;
5) separate the cohesive category into a) laccustrine clay and b) glacial tills, to differentiate between these two types of materials.

THE REVISED CLASSIFICATION SCHEME

Based on discussions above, the following represents the revised classification scheme for use in the Lake Michigan Potential Damage Study.

Geomorphic Classification

1. Cohesive Bluffs (define heights and other information as separate attributes)
    1a. Homogeneous Bluffs (sand content 0-20%)
    1b. Homogeneous Bluffs (sand content 20-50%)
    1c. Composite Bluffs (sand content 0-20%)
    1d. Composite Bluffs (sand content 20-50%)
2. Cohesive Bluffs With Beach (define heights and other information as separate attributes)
    2a. Homogeneous Bluffs (sand content 0-20%)
    2b. Homogeneous Bluffs (sand content 20-50%)
    2c. Composite Bluffs (sand content 0-20%)
    2d. Composite Bluffs (sand content 20-50%)
3. Low Bank
    3a. (Sand content 0-20%)
    3b. (Sand content 20-50%)
    3c. (Sand content >50%)
4. Baymouth Barrier
5. Sandy Beach / Dune
6. Coarse Beaches
7. Bedrock (Resistant)
8. Bedrock (Non-Resistant)
9. Open Shoreline Wetlands
10. Artificial
11. Unclassified

Shore Protection Classification

1. Coastal Armoring
    1a. Revetments
    1b. Seawalls / Bulkheads
2. Beach Erosion Control Devices
    2a. Groins
    2b. Jetties (littoral barriers?)
    2c. Offshore Breakwaters
    2d. Perched Beaches
3. Non-Structural
    3a. Beach Nourishment
    3b. Vegetation Planting / Bioengineering
    3c. Slope Grading / Bluff Stabilization
4. Protected Wetlands
5. Ad-Hoc
    5a. Concrete Rubble
    5b. Other Materials
6. Unclassified

Nearshore Subaqueous Classification

1. Cohesive (Till)
   - 1a. Thick Sand Cover (>200 m3/m)
   - 1b. Moderate Sand Cover (50-200 m3/m)
   - 1c. Thin Sand Cover (<50 m3/m)
2. Cohesive (Laccustrine Clay)
   - 2a. Thick Sand Cover (>200 m3/m)
   - 2b. Moderate Sand Cover (50-200 m3/m)
   - 2c. Thin Sand Cover (<50 m3/m)
3. Cobble / Boulder Lag Over Cohesive
4. Sandy
5. Bedrock (Resistant)
6. Bedrock (Non-Resistant)
7. Unclassified

RECOMMENDATIONS FOR APPLICATION TO THE LAKE MICHIGAN SHORELINE

In carrying out the revision of the classification scheme above, consideration was given to the level of effort required to input the original classification data into the USACE Detroit District GIS system. Where possible, we did not want to have to "re-classify" the entire shoreline for all three classification categories. Ideally, it was hoped that a reclassification of the shoreline would involve a simple renaming of various categories, or a combining of similar categories. Unfortunately, the level of detail that is being sought for input into the overall coastal process and potential damages model requires some reclassification to be carried out and other similar issues to be addressed. These are discussed below.

Scale

The various data that are required for input to the model currently exist in various scales in the GIS database. Recession rate data for example, are input in a kilometer-by-kilometer fashion, as are land use, land use trend, and ownership data (input during this study). Shore type data are input at various scales, with the main control being the linear extent over which a geomorphic shore type occurs. There are approximately 130 "geomorphic reaches" along the Lake Michigan shoreline, while there are over 2400 kilometer reaches.

To create a level of consistency in the database and also to provide an easier means of data input to both the coastal processes model being developed by Rob Nairn and the Recession Rate Land Use Analysis System being developed by ourselves, we are proposing that all shore classification data be input on a kilometer by kilometer basis. This will make the shore classification data consistent with other

data sets on land use, land use trend, recession rate, ownership etc. and will allow for more robust search capabilities in the Recession Rate Land Use Analysis System.

It is expected that "conversion" of the existing shore classification data into 1 kilometer increments can easily be done in an automated fashion using the USACE GIS. If not, a manual conversion can be carried out using shore classification/land use maps and tick marked topographic maps that we already have in our possession. It is anticipated that this conversion of the existing classification data can be completed prior to the start of any reclassification and that it can be incorporated into the kilometer by kilometer database being prepared for the Recession Rate Land Use Analysis System.

Conducting the Actual Classification

Generic Activities

In carrying out the reclassification there will be a number of generic activities that will need to take place within each of the classification categories. They are described briefly here. Further details are provided during a discussion of the specific changes required that follow

Overflights – In order to obtain the most comprehensive coverage of the shoreline in the shortest period of time, we are recommending that the entire Lake Michigan shoreline be flown via helicopter at appropriate heights and speeds and that the shoreline be videotaped and photographed. Such an activity will:

- assist in the verification of many aspects of geomorphic shore type;
- assist in the gathering of new required information on shore type;
- assist in the classification of visible nearshore data; and
- provide detail on types of shore protection present.
- provide an up to date record of 1997-1998 Lake Michigan shoreline conditions. This will likely also include aspects related to shoreline use and development.

It is proposed that the shoreline be flown with the assistance of a U.S. Coast Guard helicopter (as per discussion with USACE Detroit District staff), which carries on-board GPS and narration (audio) equipment. These will allow "geo-referencing" of the video tape and audio narration of features observed for input into the kilometer-by-kilometer database. Where possible, it is recommended that one coastal engineer and one coastal geologist be on board for observation, documentation and narration purposes.

Site Specific Investigations – In areas of complex geology, bathymetry, or shore protection design, it may be necessary to conduct site specific observations along the shoreline in order to verify or clarify things seen from the air. This can be done

via land-based field visits to specific sites, or preferably via boat trips close to shore along the areas of interest (similar to that conducted for St. Joseph to Shoreham this past summer). This would allow us to not only get a better handle on shore type, nearshore conditions and shore protection data along regional sections of shoreline, but may also assist in determining the composite nature of, for example, bluff shorelines, or sand content of other shore types.

Examination of Existing Data - Existing shore profiles, bathymetry data, SHOALS data, geologic and stratigraphic data, etc. will need to be examined for details related to bluff stratigraphy and composition (e.g., Graham Larson's work), nearshore bottom type, sand content, etc.

GIS Manipulations - There are a few categories where the "reclassification simply involves re-naming or re-labeling existing entries in the GIS database. These are identified in the specific discussions that follow.

Peer Group Consensus – While the actual reclassification of the Lake Michigan shoreline should be conducted by a small group of individuals for consistency purposes, it will be important to ensure that there is a peer group consensus of the revised data. This will be accomplished by presenting reclassified data (including videotapes and photos of “new” shore types, etc.) to the Advisory Committee as well as to selected individuals or agencies within each state. Note, we are not asking these individuals to classify the shoreline as was done within the Reference Study, but rather to simply verify that our classification is correct.

Specific Activities

Geomorphic Shore Type

Cohesive Bluffs and Bluffs With Beach – The height factor for the cohesive bluffs category has been removed. Thus, High Bluffs (1) and Low Bluffs (3) in the original classification become “Cohesive Bluffs” (1) in the new classification. Similarly, high bluffs with beach (2) and low bluffs with beach (4) become “Cohesive Bluffs With Beach (2). Accomplishing this reclassification will involve a simple re-labeling activity within the GIS database. The new bluff categories also have subclasses based on their composition and sand content. This results in the elimination of the Composite (15) category from the original classification. Reclassification into these categories will need to be completed through review of data on stratigraphy and composition and possibly through analysis of information collected from overflights or site specific field investigations. Data on bluff height will also need to be added and would be obtained through investigation of topographic map sheets or other suitable means. Bluff height data where appropriate and available would be entered for each 1 km reach along the shoreline.

Low Banks – The IJC categories labeled Sandy / Silty Banks (5), Clay Banks (6) and Low Riverine / Coastal Plain (12) have been combined into a new category called “Low Banks” (3). Accomplishing this reclassification will involve a simple re-labeling activity within the GIS database. The Low Banks category also has subclasses based on sand content (3a-c). Reclassification into these categories will need to be completed through review of data on stratigraphy and composition and possibly through analysis of information collected from overflights or site specific field investigations.

Semi-Protected Wetlands – The Semi Protected Wetland category (14) from the original classification has been removed. Where this category was applied to a baymouth barrier protecting a wetland, the class will need to be changed to the new Baymouth Barrier category (4). Where the Semi Protected class was used to define a wetland protected by a dyke or other man made containment structure, the geomorphic shore type will need to be changed to Artificial (10) and also assigned a new shore protection classification of “Protected Wetlands” (SP4).

Sandy Beach / Dunes – This class has been retained but will need to be renumbered from 7 to 5.

Coarse Beaches – This class has been retained but will need to be renumbered from 8 to 6.

Bedrock (Resistant) – This class has been retained but will need to be renumbered from 10 to 7.

Bedrock (Non-Resistant) – This class has been retained but will need to be renumbered from 11 to 8.

Artificial – This class has been retained but will need to be renumbered from 17(?) to 10.

Unclassified – This class has been retained but will need to be renumbered from 16(?) to 11.

Shoreline Protection Classification

Shoreline Protection Classification – The entire shore protection classification is going to be redone and will shift from data on extent or level of shore protection to the actual type and intent of shore protection present. Reclassification is proposed to take place on a 1 kilometer reach basis. Data will be collected through overflights of the shoreline, site specific field investigations, and examination of all other possible data sources.

Nearshore Subaqueous Classification

The nearshore subaqueous categories will undergo some reclassification and refinement, particularly for the cohesive classes. This is hoped to provide more detail on specific composition of nearshore cohesive sediments as well as detail on amount of sand cover present. As there was a significant lack of detailed nearshore data for the initial classification, efforts will also be made to gather additional data in all nearshore categories.

Clay – The Clay category (NS1) from the original classification has been expanded and renamed to "Cohesive (Till)" (1) and "Cohesive (Laccustrine Clay)" (2) to reflect the types of cohesive sediments found in the nearshore. These two categories also have subcategories based on thickness of sand cover. Data to conduct this reclassification will need to be obtained from overflight data (where visible), site specific field investigations and examination of other data sources including SHOALS data, GPR, side-scan sonar, profile information etc.

Sand / Gravel Lag Over Clay – This category has simply been renamed to "Cobble / Boulder Lag Over Cohesive." It is anticipated that additional data on the extent of this shore type can be obtained through examination of nearshore profiles, SHOALS data and other nearshore data, and possibly through information and observations carried out during the shoreline flights. Some investigation may be required to ensure that any reaches with a sand cover present previously included in this category now fall into the sand cover over cohesive categories (1a-c or 2a-c).

Sand – This category has been retained but will need to be renumbered from 2 to 4. Some investigation may be required to ensure reaches classed as sand do not fall into the thick sand cover over cohesive categories (1a or 2a).

Bedrock (Resistant) – This category has been retained but will need to be renumbered from 4 to 5.

Bedrock (Non-Resistant) – This category has been retained but will need to be renumbered from 5 to 6.

Unclassified –This category has been retained but will need to be renumbered (where it still applies) from 6 to 7.